Journal of Systemics, Cybernetics and Informatics (2022) 20(7), 154-172
https://doi.org/10.54808/JSCI.20.07.154

Rethinking Sustainability: Mapping microclimatic conditions on buildings as a regenerative design strategy

Ana Zimbarg

Florida International University
aczimbarg@gmail.com

Abstract[1]

Once humankind became aware of environmental problems, more opportunities were open for research and discoveries, which expanded the boundaries, and gave force to sustainability in architecture. However, in sustainability, any damage caused by human development is not considered, and in numerous cases, the term is misused. Many interventions are underpinned 'green' and 'sustainable' but are unable to provide any benefit to the environment. This misconception reflects the individualistic attitude that human development has concerning the planet. Therefore, considering the built environment as part of the natural environment can be beneficial in developing different strategies for producing sustainable and regenerative projects. Combining nature with architecture can help to trigger empathy and respect, generating new relationships between humans and nature. This paper will critique the misappropriation of the term sustainability and exhibit concepts of regenerative design, which will scaffold a conceptual framework of treating the building as part of the landscape. The relevance of the presented framework is that the building is thought of as a feature in the landscape that creates microclimatic conditions for various plant habitats, and it has the potential to become a tool to include regenerative principles in the urban context.

Keywords: *biodigital architecture; bio-design; ecological architecture; sustainability; regenerative design*

1. Introduction

Now that climate change has reached critical levels, humankind is rushing to make amends with nature[2]. Architecture and design could be valuable tools

[1] Peer editing and final proofreading for this article by Thomas Marlowe of Seton Hall University.
[2] With linguistic evolution in popular language, scientists and philosophers have remained cautious with this word. In this paper, 'nature' is a term embracing but not limited to scientific concepts such as "biodiversity", "evolution", "ecosystem", "landscape", "wildness", "population", and "community"; the whole of material reality, considered as independent of human activity and history (Ducarme & Couvet, 2020).

to disseminate a less anthropocentric mode of reasoning and help us succeed in this challenge. The term "sustainability" implies a set of cultural symbolisation, which includes sciences and discussions of sociology; it formulates quantitative and qualitative measures for survival over and against extinction, preservation over and in opposition to destruction (Building Codes Board, nd)

Urban spaces pose many challenges regarding climate change at an overwhelming speed pressuring the need to optimise urban environments without increasing the adverse effects that human settlement causes in the native habitat. The natural environment provides varied benefits to humans, referred to as ecosystem services. Human progress requires the appropriation of an ecosystem's goods and services, such as climate regulation, salinity control, soil formation, nutrient cycling, pollination, and waste assimilation (Pedersen Zari, 2018) The climate issue has been exhaustively discussed. It has impacted architectural debates, and sustainability has become popular and commercialised.

This paper will present a design method to acknowledge the human-made spaces as part of the natural surroundings. Two main critiques are scaffolding the presented framework: the first one is related to misconceptions about sustainability. Although sustainability reduces environmental harm, it does not rectify past/continuing imbalances in the natural environment (Birkeland, 2019). Ecological restoration and urban ecology emerged in the 1970s, and it was focused on the study of the ecosystem in developed areas. In the 1990s, it evolved into a branch of sustainable design advocating urban revitalisation and improving the connection between communities and nature. However, modelling "green cities" or "green buildings" does not inspire designing cities as generators of ecosystems (Birkeland, 2019).

The second critique relates to our attitude concerning the current paradigm regarding our relationship with the planet. We call it the Anthropocene, a time when humans changed the planet forever and for everyone. These changes are consequences of human activities (Haraway, 2016) and are inflicted on all other species. Nevertheless, the term posits that the human species are the dominant Earth-shaping force, reinserting 'humankind' into nature only to 'elevate' our kind (Baskin, 2019). This reflects the individualistic attitude intrinsic to capitalism. In her book 'Staying with the trouble', Donna Haraway states that "it is unthinkable to do good work on the premises of individualism and human exceptionalism" (Haraway, 2014). Therefore, changing the way we design our cities can be a way to shift this paradigm.

Architecture and design can be a medium of communication through aesthetic experiences (de Bérigny & Woolsey, 2011). Pasquero and Poletto's work uses aesthetics as a meta-language to enable communication between the human and non-human. Pasquero and Poletto see architecture as something that can contribute to other disciplines, and that design can be a bridge between humans and other species (Pasquero & Poletto, 2020; Poletto, 2017). Hence, including nature in architectural design can be a way of addressing the necessity of change. Meyer (2008) believes that the experience of beauty is a critical component of an environmental ethic, and explains that an immersive and aesthetic natural world experience can lead to recognition, empathy, love, respect, and care for the environment. She says that experiencing “hyper nature-designed” landscapes that reveal and regenerate natural processes and structures and that artistically exploit the medium of nature is restorative. To Meyer, experiencing nature works on people's psyche generating the chance to ponder a world outside oneself. Incorporating nature into architecture creates ecological relationships but can also trigger this empathy and respect, generating new relationships between humans and nature.

Planning cities as an element of the natural domain is a way of rethinking our relationship with nature and redefining sustainability in architecture. Instead of separating developed zones from nature, it is worth considering our cities as another layer of nature. In other words, the building should be treated as part of the landscape as it creates microclimatic conditions for several plant habitats. This can be done through environmental analysis tools. This article will first expand the criticism on the misuse of sustainability and expose the concept of regenerative design. Secondly, it will illustrate how technology can assist as a bridge between nature and human development. Finally, a conceptual work frame will illustrate how the discussed ideas can be applied to architecture.

2. Critique on Sustainability

The concern about the environment was a gradual process that emerged in the late nineteenth century due to the reckless exploitation of natural resources. Technology influenced the emergency of environmental concerns, for example, how pesticides could have harmful effects on human beings. Once humankind became aware of environmental problems, more opportunities were open for research and discoveries. Architects then expanded their boundaries by integrating energy-saving features, such as energy-neutral buildings and renewable energy integrated systems, prompting the sustainable design initiative that gained force in the 1990s (Ducarme, 2020) The industrial revolution interweaved the idea of 'progress' with the domination of nature (Birkeland, 2019, 2020). With modernity, we came to believe that rational and organised environments that we consider our modern living habitats are part of the biosphere and that there is a machine-like model of nature that follows our logic (Poletto, 2020).

Many architects and urban designers have adopted terminologies from science such as 'metabolism', 'genetic design' and 'evolutionary design' (Tsui, 1999; Pedersen Zari, 2018) without necessarily understanding the scientific basis of the original meaning of the terms in depth. This shallow approach often results in projects that use nature purely aesthetically instead of improving the environmental performance of the built environment.

Conceptually, sustainability's goals and values have not changed much since its early years: environmental and social regeneration, social justice/equity, community building and engagement, more symbiotic human-nature relationship and so forth (Birkeland, 2019). In sustainability, any damage caused by human development is not considered (Roös, 2021) and the alleged 'sustainable' development often reduces cultural/biological diversity and irreversible ecological damage (Birkeland, 2020). It can be seen in interventions underpinned 'green' and 'sustainable' such as the redevelopment of the neighbourhood Carmel, the Montjuic Fira de Barcelona (Bougleux, 2020), or Milan's Porta Nuova development. Milan's "Bosco verticale" residential complex in Porta Nuova is a good example of sustainable misreading. Although the complex provides beautiful green scenery to the hectic heart of Milan, the buildings are unable to provide any benefit to the community or the environment.

Furthermore, the building utilises an enormous number of resources to host the weight of the 800 trees, requiring a significant amount of concrete and steel to support the terraces (Paola, 2021). This is not a disapproval of vertical gardens but a critique of the frivolous use of "green" buildings. However, adding terraces with plants that 'produces an oxygen cylinder per day' (Paola, 2021) does not make a building sustainable does not benefit the environment significantly.

3. Regenerative Design

Cities interfere in the ecology of surrounding regions as urban development implies demand for building materials and food, producing greenhouse gases

(GHG), air pollution, waste, and consequently loss of habitat and extinction. In addition to chemical interference, urban development brings challenges to local ecosystems by introducing invasive species, increasing competition, and changes in soil and water chemicals contributing to biodiversity loss. One of the main issues with biodiversity loss is ecological imbalance's influence on climate change (Billing, 1988). For humans, it means that we are susceptible to more disaster impacts, degrading urban areas and impacting people. So, if ecological knowledge were part of architecture and urban design decisions, cities would become vital players in global efforts to restore and sustain biodiversity (Pedersen Zari, 2015).

Regenerative design theories emerged from early sustainable development, which attempted to integrate environmental responsibility, social equity, and economic viability (Dunlap & Mertig, 2013). They describe a number of regenerative design outlines such as permaculture, developed by Holmgren, Rodale's regenerative organic agriculture, or ecological design, where Van Der Ryn describes restoration and regenerative strategies. Lyle's idea of regenerative design is the most relevant framework for this article. He expanded the concept, added more layers of complexity, and questioned the linear approach that urban systems had been developed.

In 1994, Lyle proposed a regenerative design concept as a tool for sustainability that suggested that a circular logic should be part of urban spaces by reincorporating the essential elements of life such as energy conversion, water treatment and nutrient cycling in human-designed spaces. Lyle's theory focuses on designing landscapes to support ongoing supplies of energy and materials for habitat, daily living, and economic activity. Accomplishing this regenerative state replaces the linear material flow system with cyclical flow outsources (Dunlap, 2013).

Unlike the "green architecture" approach, designed to benefit only humans, Lyle's method supports the "coevolution of human and natural systems" so that both natural and social capital are supported. This design model considers cultural, social, economic, and environmental aspirations. Additionally, the singularities of each locality, referred to by John Lyle as the 'uniqueness of place', need to be understood and evaluated. He explains the fundamentals of understanding the 'uniqueness of place' in his article "Can floating seeds make deep forms?". In this article, the author reflects on the primary modes of ecological order and later adds layers of complexity to his theory by integrating 'human ecosystems'. "Human ecosystems" refers to areas where humans and natural processes interact (Billing, 1988). When human settlement intervenes in the existing ecological system, a process should be put in place to regenerate the resources used by nature (Dunlap, 2013)(Elenberg Fraser, nd)

Lyle's regenerative design establishes that the landscape must be designed to support ongoing supplies of energy and materials for the habitat, daily living and economic activity of a given population. Sustainable design, to John Lyle, endeavours to minimise harm and have a neutral impact on the environment. Therefore, sustainability does not consider the ecosystems as damaged or lost by human intervention (Roös, 2021). Lyle's concept of the "uniqueness of place" inserts complexity into the landscape design and the architect's role concerning the environment. He explains that landscape throughout time has been conceived in a superficial manner, where the architects were only interested in what was seen on the surface. Lyle called this approach "shallow form" (Lyle, 1991) and proposed that the landscape should be a "visible manifestation of an ecosystem". If human development does not consider the natural orders, its implementation will result in ecological disorder and instability. These natural orders comprise considerations regarding the living and non-living systems. Other modes of ecosystem order are described as "the functional system", which relates to the flows of energy and materials that distribute the necessities of life to all species included in the structure". Each ecosystem has a specific requirement; for example, too much or too little flow of water and nutrients disrupts the system (Lyle, 1991).

To illustrate what would Lyle's regenerative landscape would look like, it is important to mention what he called "Natural reserves", which are "the areas of the garden left untended but protected" (Young, n.d.). He would envision these protected spaces as libraries of species, communities, and ecosystems to remind us "how nature works without the added complications of human technology". Additionally, the regenerative design would have sections of no human intervention and transition regions that are zones for testing and experimenting with regenerative strategies. These are the regions allocated for "hunting, fishing, recreation or almost anything else that might be managed sustainably” (Young, n.d.).

Lyle's examples relate to large territories; however, this concept can be revisited and applied inside cities, creating more transition areas and generating more opportunities to develop more and new ecological relationships. Lyle suggests that in a regenerative world, the governing metaphor for the human relationship with nature should be a 'global garden' that, in contrast with today's landscape, will blend and merge smoothly with the urban setting (Young, n.d.). To design something that is not a "shallow form," the regenerative, merging component needs to be incorporated into the planning process.

4. Design for Nature

Urbanised green spaces become islands and refuges for animal and plant biodiversity. One of the roles of having adequate vegetation in the urban context is that it supplies appropriate sites for food, shelter, and nesting areas. Plants are crucial for the survival of metropolitan fauna; nonetheless, the urban environment has negative anthropogenic factors such as pollution, heat island, and soil scarcity, meaning that the selection of plants must be thorough (Fineschi & Loreto, 2020).

There are many examples of architects interested in environmental conservation. Brazilian landscape architect Roberto Burle Marx, one of Latin America's finest modernists, is known for his insistence on using Brazilian native plants in his projects and his outstanding contribution to the ecological conservation of Brazilian forests. He catalogued and collected species from various regions of Brazil in the 1960s (Lyle, 1991). There are current initiatives to convert urban environments into gardens to increase the ecological base, such as "Green Scaffolding” (G.S.), which is a concept for a modular system that wraps around the façade of an existing building providing multiple ecosystem services and environmental amenities (Meyer, 2008). Such structures can be established in different sizes, types, and scales. These projects can enable cities to blend into the landscape, creating opportunities for urban farming and reducing truck transport to and from cities. Furthermore, it can provide thermal comfort, help with urban acoustics, or serve as shelter for local species from invasive species, depending on the design (Meyer, 2008).

Although these initiatives are a positive manifestation of addressing ecology and climate issues in urban areas, they do not contribute to a paradigm shift. There is a clear separation between built-up areas and nature, meaning that the projects are not contributing to reevaluating the essential human-nature relationships. The green scaffolding, green roofs, urban farming, and conservation projects are initiatives exclusively human-centred.

However, projects such as Illura Apartments and the River Rouge Ford Plant in Michigan have some strategies that contribute to ecology. The River Rouge Ford Plant created a prairie using local grasses that support the local ecosystems (greenroofs.com, n.d.). Illura Apartments (Figure 1 a & b) in

Melbourne, Australia (Elenberg Fraser, n.d.) has a green façade that was reseeded with grassland species that have been extinct in the area since colonisation, resulting in a resilient green façade that restored the native ecosystem.

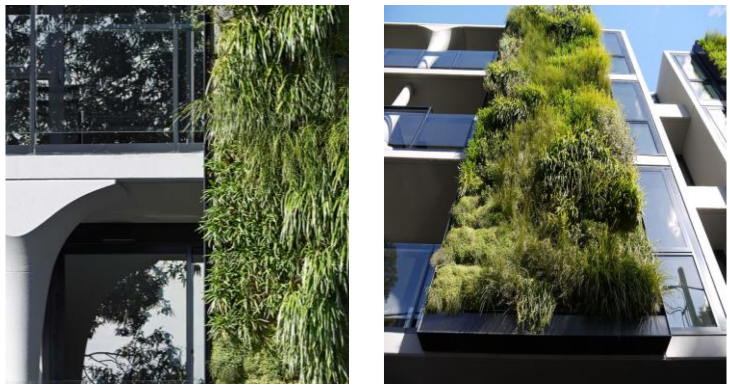

Figure 1a & 1b: Illura apartments façade in West Melbourne, Australia. Melbourne Botanical Gardens have provided the grassland seeds as an initiative to restore the species in the area. Photography by Peter Clarke.

5. Case Study: Technology Assisting Nature-inclusive Design

Although complete regeneration may not be achievable, providing opportunities and spaces for nature to establish relationships that strengthen ecosystems may be an approach to straightening human-nature relationships. Integrating technologies such as BIM with a geographic information system (GIS) is a framework that can capture and analyse spatial and geographic data. (Hambarde, 2013). GIS provides critical mapping and overlays analysis to master planners early in the design process (National Geographic Society, 2021). Also, this technology can lead to design decisions that will strengthen natural ecosystems. Moreover, it exposes how digital technology plays a significant role in merging concepts and ecology data into architectural and urban design.

GIS captures, stores, checks, and displays data related to the positions of the Earth's surface. It can map the spatial location of real-world features and visualise the spatial relationships among them or quantities, such as to locate relative minima and maxima, to find places that meet their criteria, or to see the relationships between localities. Moreover, GIS can determine what is happening or what features are located inside a specific area/region (What is GIS, n.d.). By connecting seemingly related data, GIS can assist in understanding patterns and relationships between developed and non-developed areas.

Pedersen Zari proposes a framework that involved incorporating GSI technology to integrate ecological data into the design, and it was applied in sustainable developments such as Lavasa Hill (Hambarde, 2013). Lavasa is a planned city in Maharashtra in India's Mumbai-Pune region, covering over 2000 ha. The local monsoon ecosystems and organisms inspired the design approach to solve sustainable urban design challenges related to rainwater management and erosion control. Through infiltration and managing runoff, values near those obtained from the native forest could be reached in the built environment. The technical solutions applied were: rooflines designed to create wind turbulence to facilitate evaporation; green roofs to slow water flows; infiltration swales; massive revegetation using hydroseeding; and dams to store rainwater (Dunlap, 2013).

In the interdisciplinary approach employed to redevelop Lavasa, architects and urban designers analysed the capabilities of Geographic Information System (GIS) to solve urban design tasks. During the master planning process, building footprint simulations were drawn in CAD software. Then the building heights were proposed to the CAD models using attribute transfer based on a special overlay. The sloping roof was prescribed as a common thread amongst all buildings, and the footprints were extruded by building heigh in Arc Scene. This 3D visualisation application allows visualising GIS data in three dimensions. Several iterations were run to conclude the best volumetric configuration (Hambarde, 2013).

While BIM can evaluate the project using information embedded in 3D models and assist with decisions during site plans, GIS supports the spatial context view of the site and quantitative assessment of environmental impacts. The geographic information system can provide climate data, whereas BIM contains information about the building and its materials (Hjelseth, E. & T.K. Thiis, 2008). Assessing GIS data can help determine the potential impact of construction projects on the environment as well as technical and infrastructural constraints (Liu, X., Wang, X., Wright, et al.,2017). as done on the implementation of the A99 Expansion project – a motorway between Munich and Haar in Germany (Schaller et al., 2017). Pedersen Zari's project is an excellent example of using architectural elements to interact with the natural elements.

6. Framework to Design Buildings as a Landscape Feature

The Lavasa Hill project did benefit the local ecosystems, but the main objective was to generate a better quality of space in the public realm. To include the natural order in building design is valuable to acknowledge the building as a feature in the landscape that creates microclimatic conditions for various plant habitats. Therefore, this section will present a framework using environmental analysis tools to identify the microclimates created on the exterior surfaces of a building. Mapping the building shell will allow identifying the species of plants that could thrive in specific microclimates to propose a planting scheme for green walls, green roofs, and the immediate surroundings.

6.1. Environmental Analysis

Open-source platforms such as Grasshopper and Dynamo, along with their plug-ins, have made the integration of environmental data more accessible. A better understanding of climate data and human comfort indices impacts the designing of resilient and energy-efficient buildings (Schaller et al., 2017). Plugins such as Grasshopper's (Rhino 3D) environmental analysis plugins are used within architectural design environments to offer a socio-ecological analysis during the design decision-making (Liu et al., 2017). This tool allows the designer to know the environmental conditions that characterise a given urban environment to mitigate the adverse effects and exploit the positive ones to ensure optimal comfort conditions (Gherri et al., 2018).

Ladybug tools are one of the standard environmental tool analyses, and it has been selected because they can cope with complex and straightforward geometry (Naboni et al., 2017). Ladybug imports standard EnergyPlus Weather files (.EPW) into Grasshopper and Dynamo. It provides a range of 2D and 3D interactive climate graphics that help the decision-making process during the early stages of design. The plug-in supports evaluating initial design options through solar radiation studies, view analyses, and sunlight-hours modelling.

Honeybee provides detailed daylighting and thermodynamic modelling that tends to be most relevant during the mid and later design stages. Specifically, it creates, runs, and visualises the results of daylight simulations using Radiance, energy models using EnergyPlus/Open Studio, and heat flow through construction details using Berkeley Lab Therm/Window. It accomplishes this by linking these simulation engines to CAD and visual scripting interfaces such as Grasshopper/Rhino and Dynamo/Revit plug-ins. Butterfly is a Grasshopper/Dynamo plug-in and object-oriented Python library that creates and runs computational fluid dynamics (CFD) simulations using OpenFOAM. At present, OpenFOAM is the most rigorously validated open-source CFD engine. It can run several advanced simulations and turbulence models (from simple RAS to intensive LES). Butterfly is built to quickly export geometry to OpenFOAM and run several standard airflow simulations applicable to building design. This includes outdoor simulations for urban wind patterns and indoor buoyancy simulations for thermal comfort and ventilation effectiveness (Schaller et al., 2017).

6.2. Microclimate

We all know something about the physical processes and factors creating a microclimate: solar radiation warms the Earth's surface, evaporation increases air humidity, wind cools, and a tree casts a shadow. The microclimate should be investigated, mainly when assumed it will deviate strongly from the macroclimate and when it seems to affect the local distribution of plants and animals and their communities and the local survival of populations (Stoutjesdijk & Barkman, 2014).

The ecological concept of microclimate depends on the question being addressed. The mountainside or a desert section is considered a microclimate to a landscape ecologist. In contrast, to a reproductive ecologist interested in mosquitos, the term microclimate refers to the interior of a plant (Stoutjesdijk & Barkman, 2014). 'Plant microclimate' describes sun, shadow, temperature and humidity conditions in each location within a macroclimate. Plants and animals experience the microclimate of the exact location where they live, for example, in full sun, wind at the top of a tree or in the shade, stillness, and humidity at its base. It is different from the meteorologist's climate (macroclimate). The physical processes and factors creating a microclimate: solar radiation, air humidity, and wind velocity vary widely depending on the physical conditions of the surroundings and affect the local distribution of plants and animals and their communities and the local survival of populations (Seavitt Nordenson, 2014; Stoutjesdijk & Barkman, 2014).

Changes in temperature and humidity are most significant near the ground, absorbing a high proportion of the Earth's share of the sun's energy. When the sun shines on the ground, the surface temperature rises, and a temperature gradient is set up. Since the relative humidity of the air is related to the saturation vapour pressure, which is directly related to the temperature, the gradients of temperature and near the surface typically mean that gradients of relative humidity also exist (Unwin, 1978).

6.3. Proposed Framework

Analogous to a tree, the microclimate on the top of a building will differ from the bottom, requiring different architectural solutions. Environmental tools such as Ladybug can be a way of mapping these different microclimates throughout a building shell. Therefore, understanding the parameters that define microclimates will determine the parameters that need to be assessed by the Ladybug plugin.

The proposed workflow involves presenting to the grasshopper plugin, Ladybug, a context geometry, and a subject building. The subject location presented in this paper is a random site in Melbourne, Australia (Figure 2). There were no urban planning considerations as the purpose of this exercise is exclusive to illustrate the framework.

Figure 2: with building geometry highlighted in red. 3D image by author.

The attributes, and the requirements that define microclimates, are the parameters used to perform the environmental analysis. Dennis Unwin, from the Department of Zoology at Cambridge University, explains that painting a picture of the climate requires a knowledge of how the temperature the humidity parameters vary. Since the driving force behind the whole system is the sun, it is also essential to measure solar radiation and its variation with time. (Unwin, 1978).

The environmental tool is set to analyse the whole building's mean radiant temperature, humidity, and sun exposure. The analysis period relevant to determining a microclimate is the hot and cold, extreme temperatures. Consequently, the analysis period will be 24 hours during midsummer (Figure 3a, 3b) and mid-winter (Figure 4a, 4b).

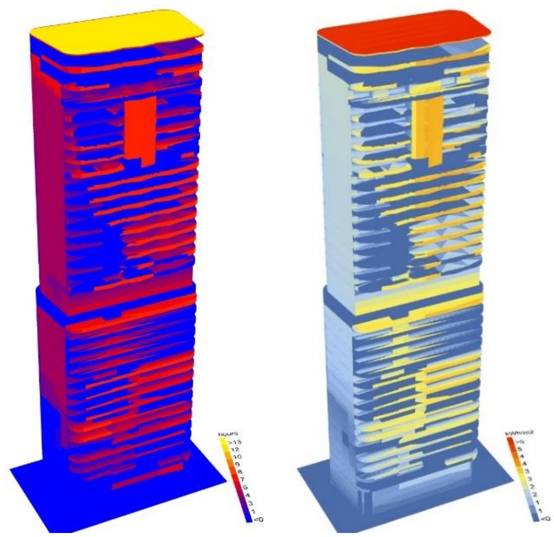

Figure 3a & 3b: Analysis of direct sun hours (a) and mean radiant temperature (b) in summer. 3D image by author.

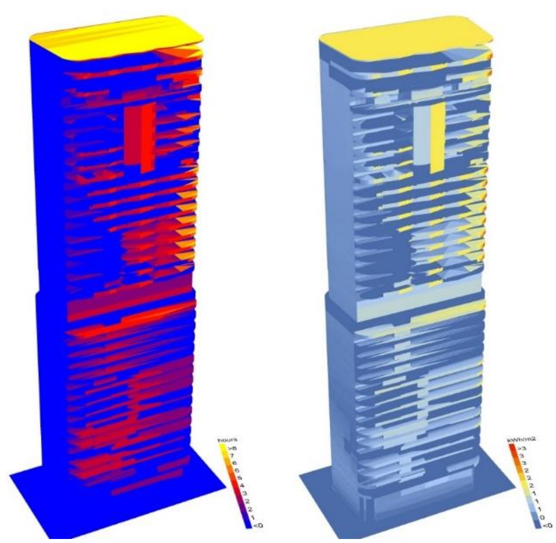

Figure 4a & 4b: Analysis of direct sun (a) and mean radiant temperature (b) in winter. 3D image by author.

Each of these analyses will build a set of data: the sun hours, the surface temperature throughout 24 hours and the relative humidity (Figure 5) during the analysed period.

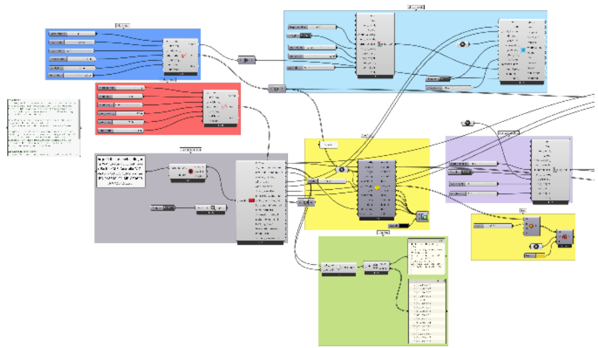

Figure 5: Grasshopper definition showing relative humidity data marked in dashed red lines. Grasshopper definition by author and scripting by Ezequiel Lopez.

The surface temperature calculation requires a material. For the example presented in this paper, a generic material was selected to simplify the calculations. A Python script for Grasshopper compared the analysis result with the parameters that define microclimates (Table 1). The outcome is a coloured geometry, where each colour represents distinctive climate conditions (Figures 6 & 7). This information will help select and populate the building façade with suitable plant species, as the analyses provide details of the building shell's particular conditions.

Table 1: Table illustrating the definition of different microclimates. (Australian Climate Averages - Climate Classifications, n.d.) (Building Codes Board, n.d.). Image by author.

Climate	Station number	Monthly mean daily global solar exposure (kwh/m2)		Min temperature celsius of year (2012 to 2022)	Max temperature celsius of year (2012 to 2022)	RelativeHumidity in Summer	Relative Humidity in Winter
Climate A	83085	1.39	7.83	-10.4 to -7.6	21.5 - 28.2	10	50
Climate B	96033	3.67	4.08	-8.1 to -14.2	26.6 - 32.3	70	45
Climate C	75032	4.89	5.31	-4.6 to -2.2	39.5 - 47.2	10	33
Climate D	15135	6.00	6.44	6.2 - 8.5	41.9 - 45.6	27	25
Climate E	14932	6.11	6.50	4 - 8.5	40.6 - 43.1	45	30
Climate F	28004	5.78	6.17	5 - 10.3	35.7 - 41.7	25	10
Climate G	14142	5.47	6.03	12 -15.9	35.8 - 36.8	15	41

Figure 6a &6b: Each colour represents a different microclimate, resulting from the cross-reference between the site conditions and the microclimate parameters. The figure on the left shows the front façade and the figure on the right the back of the building. 3D image by author.

Figure 7: Microclimate analysis in the urban context. 3D image by author.

7. Conclusion

The Anthropocene is when humans changed the planet forever because of the irresponsible development and use of resources. The term suggests that the human species are the dominant Earth-shaping force, reinserting 'humankind' into nature only to 'elevate' our kind, reflecting the individualistic attitude intrinsic to capitalism and changing the way we design our cities can be a way to shift this paradigm.

Although sustainability reduces environmental harm, does not rectify the man made imbalances in the natural environment; what is more, there is a clear separation between developed areas and nature as green scaffolding, green roofs, urban farming, and conservation projects are initiatives exclusively human-centred.

Architecture and design can be a medium of communication through aesthetic experience and contribute to other disciplines. Furthermore, design has the potential to connect humans and other species. Including nature in architectural design can be a path to addressing the necessity of change.
Analogous to a tree, the microclimate on the top of a building will differ from the bottom, requiring different architectural solutions. Environmental tools such as Ladybug can be a way of mapping out these different microclimates throughout a building's exterior. The environmental analysis is set to evaluate the whole building's climatic conditions, resulting in a coloured geometry, where each colour represents a distinctive microclimate. This information will help select and populate the building façade with suitable plant species, as the analyses provide details of the building shell's particular conditions.

This graphic representation can be used to select the suitable plant species for the building façade, but it can also assist in decision-making concerning the building volumetry. For example, the environmental analysis can be rerun after the plant selection and guide design decisions to protect the plants from wind or increase shading or sunlight. The development of this environmental analysis tool is valuable to facilitate the incorporation of regenerative solutions in the built environment. The difference between adding a traditional green wall to a building and this framework is that the design is done for the vegetation to thrive instead of populating buildings with plants to suit the indoor conditions only. This method also addresses the philosophical issue of our anthropocentric behaviour as it includes nature not only as part of the design but also as a "user" of the architectural space.

11. Acknowledgments

Conflicts of Interest: The author declares no potential conflicts of interest concerning this article's research, authorship, and/or publication.

The author wishes to thank Thomas Marlowe of Seton Hall University for his careful proofreading and detail editing, and for his constructive suggestions for this article.

References

1. Australian Climate Averages - Climate classifications. (n.d.). Retrieved March 31, 2022, from http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp
2. Baskin, J. (2019). Paradigm Dressed as Epoch: The Ideology of the Anthropocene. Time Environmental Values, 17, 9–29. https://doi.org/10.3197/096327115X14183182353746
3. Billing, J. C. (1988). Design for human ecosystems: Landscape, land use and natural resources. Landscape and Urban Planning, 16(3), 291–292.
4. Birkeland, J. (2019). Net-positive design and sustainable urban development. Net-Positive Design and Sustainable Urban Development, 1–386. https://doi.org/10.4324/9780429290213/Net-Positive-Design-Sustainable-Urban-Development-Janis-Birkeland
5. Birkeland, J. (2020). Sustainability Paradigms in Historical Context. Net-Positive Design and Sustainable Urban Development, 61–86. https://doi.org/10.4324/9780429290213-3/Sustainability-Paradigms-Historical-Context-Janis-Birkeland
6. Blanco, E., Pedersen Zari, M., Raskin, K. & Clergeau, P. (2021). Urban ecosystem-level biomimicry and regenerative design: Linking ecosystem functioning and urban built environments. Sustainability (Switzerland), 13(1), 1–12. https://doi.org/10.3390/su13010404
7. Bougleux, A. (2020). To Green Or Not To Green: Four stories of urban (in)justice in Barcelona. https://www.youtube.com/watch?v=Q8dUMucYN0w
8. Building Codes Board, A. (n.d.). Victoria climate zone map. Retrieved March 31, 2022, from www.abcb.gov.au
9. de Bérigny, C. & Woolsey, E. (2011). Reefs on the Edge: An Installation Artwork about Coral Reefs and Climate Change.
10. Ducarme, F. & Couvet, D. (2020). What does 'nature' mean? Palgrave Communications, 6(1), 14. https://doi.org/10.1057/s41599-020-0390-y
11. Dunlap, R.E. & A.G. Mertig. (2013). The evolution of the U.S. Environmental Movement from 1970 to 1990: An overview. In American Environmentalism: The US Environmental Movement, 1970-1990 (pp. 1–5).
12. Elenberg Fraser. (n.d.). 0817_Illura | Elenberg Fraser. Retrieved December 4, 2021, from https://elenbergfraser.com/#!/project/illura-apartments
13. Fineschi, S. & Loreto, F. (2020). A Survey of Multiple Interactions Between Plants and the Urban Environment. Frontiers in Forests and Global Change, 3. https://doi.org/10.3389/ffgc.2020.00030
14. Gherri, B., Maretto, M., Guzhda, A., Motti, M., Giada, M. & Zannetti. (2018). Early-Stage Environmental Modeling: Tools and Strategies for Climate Based Design.
15. GIS (Geographic Information System) | National Geographic Society. (n.d.). Retrieved November 27, 2021, from https://www.nationalgeographic.org/encyclopedia/geographic-information-system-gis/

16. greenroofsGreenroofs.com. (n.d.). Ford Motor Company's River Rouge Truck Plant - Greenroofs.com. Retrieved December 4, 2021, from https://www.greenroofs.com/projects/ford-motor-companys-river-rouge-truck-plant/
17. Hambarde, A. (2013). GIS Enabled Urban Design – Lavasa A Case Study.
18. Haraway, D.J. (2014). Donna Haraway: Anthropocene, Capitalocene, Chthulucene—Staying with the Trouble - Classroom - Art & Education. https://www.artandeducation.net/classroom/video/66322/donna-haraway-anthropocene-capitalocene-chthulucene-staying-with-the-trouble
19. Haraway, D.J. (2016). Staying with the Trouble: Making Kin in the Chthulucene. Duke University Press. https://doi.org/doi:10.1515/9780822373780
20. Hjelseth, E. & T.K. Thiis. (2008). Use of BIM and GIS to enable climatic adaptations of buildings. In eWork and eBusiness in Architecture, Engineering and Construction (pp. 423–432). CRC Press. https://doi.org/10.1201/9780203883327-58
21. Liu, X., Wang, X., Wright, G., Cheng, J. C. P., Li, X. & Liu, R. (2017). A State-of-the-Art Review on the Integration of Building Information Modeling (BIM) and Geographic Information System (GIS). ISPRS International Journal of Geo-Information, 6(2). https://doi.org/10.3390/ijgi6020053
22. Lyle, J. T. (1991). Can Floating Seeds Make Deep Forms? Landscape Journal, 10(1), 37–47. https://doi.org/10.3368/LJ.10.1.37
23. Meyer, E. K. (2008). Sustaining beauty. The performance of appearance. Journal of Landscape Architecture, 3(1), 6–23. https://doi.org/10.1080/18626033.2008.9723392
24. Naboni, E., Meloni, M., Coccolo, S., Kaempf, J. & Scartezzini, J.-L. (2017). An overview of simulation tools for predicting the mean radiant temperature in an outdoor space. Energy Procedia, 122, 1111–1116. https://doi.org/https://doi.org/10.1016/j.egypro.2017.07.471
25. Paola, L. di. (2021). Milan's private Vertical Forests vs. horizontal urban greening. The Green City and Social Injustice, 25–34. https://doi.org/10.4324/9781003183273-3
26. Parr, Adrian. & Zaretsky, M. (Michael L.). (2010). Cultural Symbolization of a Sustainable Future. 281. https://www.academia.edu/29486083/Cultural_Symbolization_of_a_Sustainable_Future
27. Pasquero, C. & Poletto, M. (2020). Bio-digital aesthetics as value system of post-Anthropocene architecture. International Journal of Architectural Computing, 18(2), 120–140. https://doi.org/10.1177/1478077120922941
28. Pedersen Zari, M. (2015). Can Biomimicry Be a Useful Tool for Design for Climate Change Adaptation and Mitigation? In F. Pacheco Torgal, J. A. Labrincha, M. v Diamanti, C.-P. Yu & H. K. Lee (Eds.), Biotechnologies and Biomimetics for Civil Engineering (pp. 81–113). Springer International Publishing. https://doi.org/10.1007/978-3-319-09287-4_4
29. Pedersen Zari, M. (2018). The importance of urban biodiversity – an ecosystem services approach.
Biodiversity International Journal, 2(4), 357–360. https://doi.org/10.15406/BIJ.2018.02.00087
30. Poletto, M. (2020). BIT.BIO.BOT - Dr Marco Poletto. https://www.youtube.com/watch?v=KnOMlKdy3yY
31. Poletto, C.P.M. (2017). BioTechHUT - EcoLogicStudio :: 10 June 2017. http://www.ecologicstudio.com/v2/project.php?idcat=3&idsubcat=71&idproj=162
32. Roös, P. B. (2021). Regenerative Design, Ecology as Teacher BT - Regenerative-Adaptive Design for Sustainable Development: A Pattern Language Approach (P. B. Roös, Ed.; pp. 103–112). Springer International Publishing. https://doi.org/10.1007/978-3-030-53234-5_8
33. Schaller, J., Gnädinger, J., Reith, L., Freller, S. & Mattos, C. (2017). GeoDesign: Concept for Integration of BIM and GIS in Landscape Planning. Journal of Digital Landscape Architecture, 2017, 102. https://doi.org/10.14627/537629011
34. Seavitt Nordenson, C. (2014). Roberto Burle Marx and the conservation of brazilian forests. CELA Paper - Landscape Research Record n. 4.
35. Stoutjesdijk, Ph. & Barkman, J. J. (2014). Microclimate, Vegetation & Fauna. (1st ed.). Koninklijke Nederlandse Natuurhistorische Vereniging, Stichting Uitgeverij.
36. Tsui, E. (1999). Evolutionary Architecture: Nature as a Basis for Design. Wiley. https://books.google.com.au/books?id=B3JQAAAAMAAJ

37. Unwin, D. M. (1978). Simple techniques for microclimate measurement. Journal of Biological Education, 12(3), 179–189. https://doi.org/10.1080/00219266.1978.9654195
38. What is GIS? - Mapping and Geographic Information Systems (GIS) - Research Guides at University of Wisconsin-Madison. (n.d.). Retrieved April 16, 2022, from https://researchguides.library.wisc.edu/GIS
39. Young, T. (n.d.). “In Gaia’s Garden: Reflections on John Lyle’s Approach to Protected Areas.”